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IMMEDIATE RETRIEVAL OF VERBAL SERIES AS A FUNCTION OF STIMULUS GROUPING

William H. Sumby

October 1965

DECISION SCIENCES LABORATORY
DEPUTY FOR ENGINEERING & TECHNOLOGY
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

Project 7682, Task 768201

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FOREWORD

This research was performed at the Decision Sciences Laboratory, Electronic Systems Division, Air Force Systems Command, as part of Project 7682, Man-Computer Information Processing, Task 768201, Data Presentation and Human Data Processing.

This Technical Documentary Report has been reviewed and is approved.

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ABSTRACT

Four questions were investigated in this study. (1) Is the learning rate enhanced if disconnected words are presented visually in clusters, e.g., pairs of quadruples, rather than individually and successively? (2) If changes do occur, and in a lawful fashion, can such differences be accounted for adequately in terms of the development of differential interitem association strengths as a function of such stimulus arrangement? (3) What differences, if any, become evident in free-recall serial position curves by such organization? (4) How is the order of responding affected by clustering?

It was found that clustering will enhance learning rate, but that the limits are extremely restricted. Furthermore, it was revealed that such stimulus arrangements do affect the build-up of differential interitem association strengths, but this again is within the limits alluded to above. Apparently, differential associative strengths developed by clustering markedly affect the shapes of the serial position curves for the different groups. Further, clustering affects the strategy an individual adopts in responding. Such became evident in the typically different orders of responding for the various conditions.

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Introduction

In the present study the effects of stimulus clustering on verbal learning are examined. Four questions are investigated: (1) is the learning rate enhanced if series of words are presented visually in clusters, e.g., pairs or quadruples, rather than individually? (2) If changes do occur, can the differences be accounted for adequately in terms of the development of differential interitem association strengths brought about by such stimulus arrangement? (3) What differences, if any, become evident in free-recall serial position curves by such organization? (4) Is the relation between the order of presentation and the order of responding affected by clustering?

It is hypothesized that the number of trials required to learn a series of words will decrease as the number of words shown simultaneously per stimulus presentation is increased, within limits. That is, a criterion of one perfect recitation will be attained in fewer trials when a series is presented in pairs of words shown together than when the same words are shown singly, with an equal amount of time allowed for the inspection of each item. Likewise, fewer trials will be required with quadruples

of words shown simultaneously than with pairs. It is believed that this tendency will hold at least to a point where all of the words of a particular cluster length are always retrievable after but one presentation. The hypothesis stemmed from the notion that associations will form more readily between words seen together (simultaneous presentation) in a sequence than between the same words presented in the same order but individually (successive presentation). But again, such would be the case only if the single cluster is always within the one-trial memory span. It was believed that with clustering a more efficient recoding and storage strategy would be adopted.

It is hypothesized that more associations will form between words shown simultaneously than between words shown in the same order but successively. The effects of recency will also influence recall order. From this hypothesis it is believed that different serial effects will become evident. As the number of words per stimulus presentation is increased the serial position curves for the first trial will tend to indicate a progressive decline in recall for words from the beginning of the series and rise progressively for words from the last part of the series. That is, the words from the last part of the series will be recalled more frequently as reported by Deese and Kaufman (1957) and Sumby (1963), but the point of least recall will gradually approach the beginning of the series with increase in cluster length. The joint influence of these factors, it is conjectured, will reduce somewhat the

probability of long strings of the initial words being recalled after but one presentation, especially those presented successively. Furthermore, it will increase the probability of occurrence of longer associative strings of the later words, especially with those presented simultaneously. The conjectures were based on the notion that retrieval would be affected by clustering in the following manner. With the clustered series the cluster group presented last would be given first in the response sequences and more or less as a single intact unit rather than as a somewhat random recall from the presented series. Further, clusters other than the last would tend to be recalled in cluster groups, although not necessarily in the presented order. It is implied that the material to be learned is more efficiently encoded with clustering, that is the number of chunks, using such a presentation technique within the limits of the memory span for a particular cluster length.

Method

The stimulus materials were series of four letter monosyllabic words all 16 words in length. The frequency range of the selected words was 50 - 200 occurrences per 4 1/2 million words according to the Thorndike-Lorge L count (Thorndike & Lorge, 1944). Five different word series were developed. The words selected for each series and the word orders were accomplished in a manner which would tend to minimize phonetic or semantic associations. The words were printed

in black, 1-in. letters on white cards. Five cluster-length conditions were used: 1, 2, 4, 8 and 16 words. The words in the multiple conditions were arranged vertically on the cards. A deck of each length was printed for each series. That is, for the 2 word condition, 2 words were printed on each card, for the 4 word condition, 4 words per card, etc. The word-order was the same for all cluster lengths for a particular word series.

One hundred and twenty Northeastern University undergraduate men and women participated as Ss. Twenty-four Ss were assigned to each of the 5 cluster conditions. The group assignments were random with the exception that 12 men and 12 women were assigned to each cluster group. The Ss were told that they would be shown a series of 16 monosyllabic words printed on white cards. Each subject was made aware of the number of words which would appear on each card for the particular condition, and the amount of time each card would be available for inspection. They were also instructed that on a signal they would respond orally with all of the words they could recall, and in any order of recall. The Ss were tested individually to a criterion of one perfect recitation. The E recorded the responses and the order of recall on a prepared answer sheet.

The cards were presented at rates which would allow each word to be viewed for 2 sec. Specifically, in the 1 word series each card was presented for 2 sec., the 2 word card for 4 sec., etc. No attempt was made to control the technique by which Ss examined the cluster. Thirty-four secs. were allowed for recall following each serial presentation. The results obtained for each cluster condition were pooled over series.

Preliminary Experiment

In a preliminary experiment the average number of words which could be recalled after one trial for word series of different lengths was determined. The reason for this effort was to establish the series length at which complete recall could always be achieved on the first trial. The words had the same characteristics as the words used in the main study. It was revealed that complete one-trial recall does not occur consistently for series any greater than 4 or possibly 5 words in length.

Results and Discussion

The hypothesis that the number of trials required to learn a list of unrelated words would decrease as the number of words shown per stimulus presentation is increased is only partially supported by the data. A criterion of one complete recall is reached on the average in fewer trials with multiple word presentation than with single word presentation with one exception, the 16 word cluster: 1 - 6.71 trials, 2 - 4.92, 4 - 5.29, 8 - 6.46 and 16 - 6.71. However, criterion is met in virtually the same number of trials with the 2 and 4 word cluster, and both in fewer trials than the 8 and 16 word conditions. The average number of trials to criterion for the latter two conditions is extremely close. The criterion is met with the 1 and 16 words in the same number of trials. An analysis of variance revealed, however, that the main effect, conditions, is not statistically significant. It is interesting to

note that until criterion is reached the learning level of the 8 word group is below all of the others.

The results are, however, compatible with the notion that word associations tend to form more readily between words presented simuntaneously than between words presented successively with the exception of the 16 word group in which, of course, the entire series is shown simultaneously. The data which support the notion are summarized in Tables 1 and 2. Table 1 presents the distribution of occurrence of pairs as a function of cluster length on the criterion trial, possible 24. Those figures followed by an asterisk are successive pairs. The column labelled "Expected Successive" in Table 2 indicates

Table 1

Distribution of Occurrences of Pairs*

Pairs	Cluster Length				
	1	2	4	8	16
1-2	14*	24	22	20	17
2-3	15*	4*	22	18	17
3-4	9*	23	23	18	15
4-5	4*	7*	5*	18	13
5-6	8*	19	18	19	11
6-7	8*	5*	14	20	6
7-8	12*	17	17	19	12
8-9	8*	9*	8*	6*	10
9-10	7*	18	17	12	7
10-11	8*	11*	12	14	11
11-12	10*	15	13	11	9
12-13	8*	9*	11*	11	9
13-14	10*	13	17	10	10
14-15	9*	4*	12	12	11
15-16	6*	15	14	7	9
	136	193	225	215	167

* Indicates successive pairs

the total number of response pairs which would be expected to have been words presented successively if the simultaneous and successive pairs gained equal associative strength on the criterion trial. The

Table 2

Number of Expected Successive Pairs Compared with the Number which Actually Occurred on Criterion Trial

Cluster Length	Total Number Pairs	Expected Successive Pairs	Actual Successive Occurred
1	136		
2	193	90	49
4	225	45	21
8	215	14	6
16	167		

number of successive pairs expected in this case was determined simply by multiplying the total number of pairs recalled by that proportion of the pairs in the presented series which were successive rather than simultaneous. In each case, of course, the number of successive pairs would be less than the number of simultaneous pairs presented. It was made quite apparent in the 2, 4 and 8 word conditions that the actual occurrence of successive pairs is significantly below what would be expected if such strengths were the same. A Friedman two-way analysis of variance by ranks (Friedman, 1937) indicates the difference between the two types of associations to be significant at less than the

.001 level (X_r^2 = 17.38/2df). The analysis was made by comparing the successive pairs with the two adjacent simultaneous pairs, n - 1 and n + 1. In each case the frequency of occurrence of successive pairs is below the occurrence of simultaneous pairs, this occurs without exception. The average numbers of pairs emitted, however, for the 1 word series and for the 16 word series were found not to be significantly different.

The serial position curves for the five groups for the first trial are presented in Fig. 1. The results again only partially support the hypothesis stated in the introduction, that as the number of words per stimulus presentation is increased the serial position curves would tend to indicate a progressive decline in retrieval for words near the beginning of the series and rise progressively for words near the end of the series. The data indicate to some extent that such is the case with the 2, 4 and 8 word series, but it is not the case with the 16 word condition. With the 16 word condition the point of least retrieval is close to the end of the series, followed by an abrupt rise in retrieval at the extreme end. The rise is not of sufficient magnitude, however, to exceed any other condition at this point. The one word series follows the typical serial position pattern with free-recall for high-frequency words. The curves for the 8 word condition offer some evidence as to why the learning rate lagged behind the others. Apparently, the strategy in this case was to learn the two series, and in order of presentation. Since 8 words is

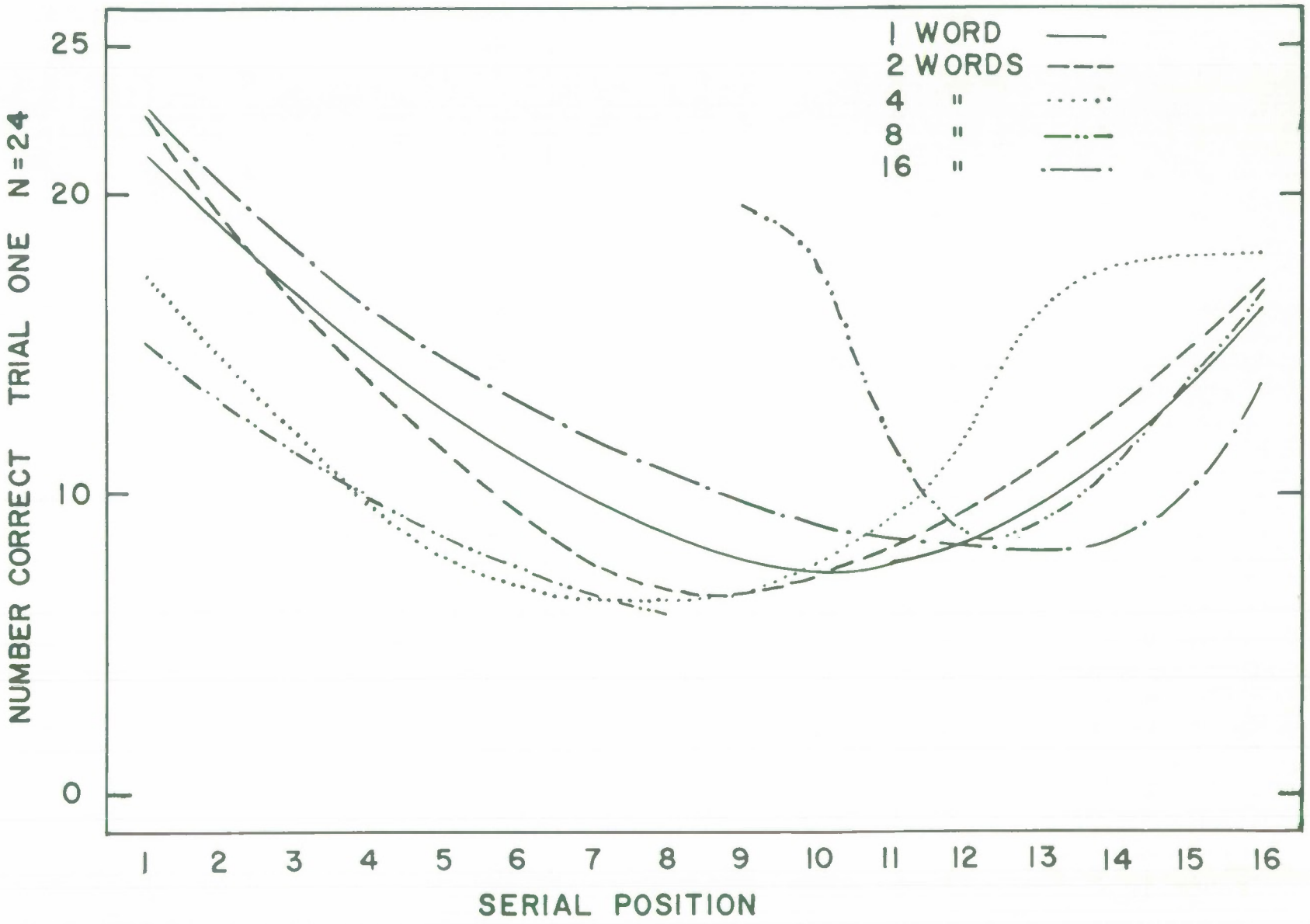

Figure 1. Serial position curves as a function of cluster condition.

typically greater than the memory span, after one presentation, two serial position tasks developed, thus causing two depressions, and thus an apparent lowering of the rate. A decline is evidenced for initial retrieval as a function of the increase in the number of words in the presentation.

Figure 2 shows the average positional order of response as a function of the serial position of the word in the presented series, e.g., the diamond at position 1 on the abscissa and 3.5 on the ordinate indicates that for the 16 word series the word emitted first on the criterion trial was on the average from the 3.5th position in the presented series. The differences in the order of responding for the different conditions are quite apparent. A horizontal line at about 8.5 on the ordinate would be evidence of more or less random retrieval from the presented list. The 1 word function approaches that condition most closely. It is interesting to note that for the 2, 4 and 8 word series the cluster near the beginning of the series, generally the first, was emitted last. Of further interest is the fact that there is a tendency for the average ordinal position to increase within a particular cluster. That is, for the 2 word cluster the second word of the simultaneous pair typically has a higher ordinal position than the first word, and in the 4 word cluster the first word tends to be lower than the second, the second lower than the third, etc. This is the case with one exception for the 2 word series, and without exception for the 4. There are some slight reversals for the 8 and 16 word conditions. In other words, there is a strong tendency for Ss to learn the simultaneously presented material

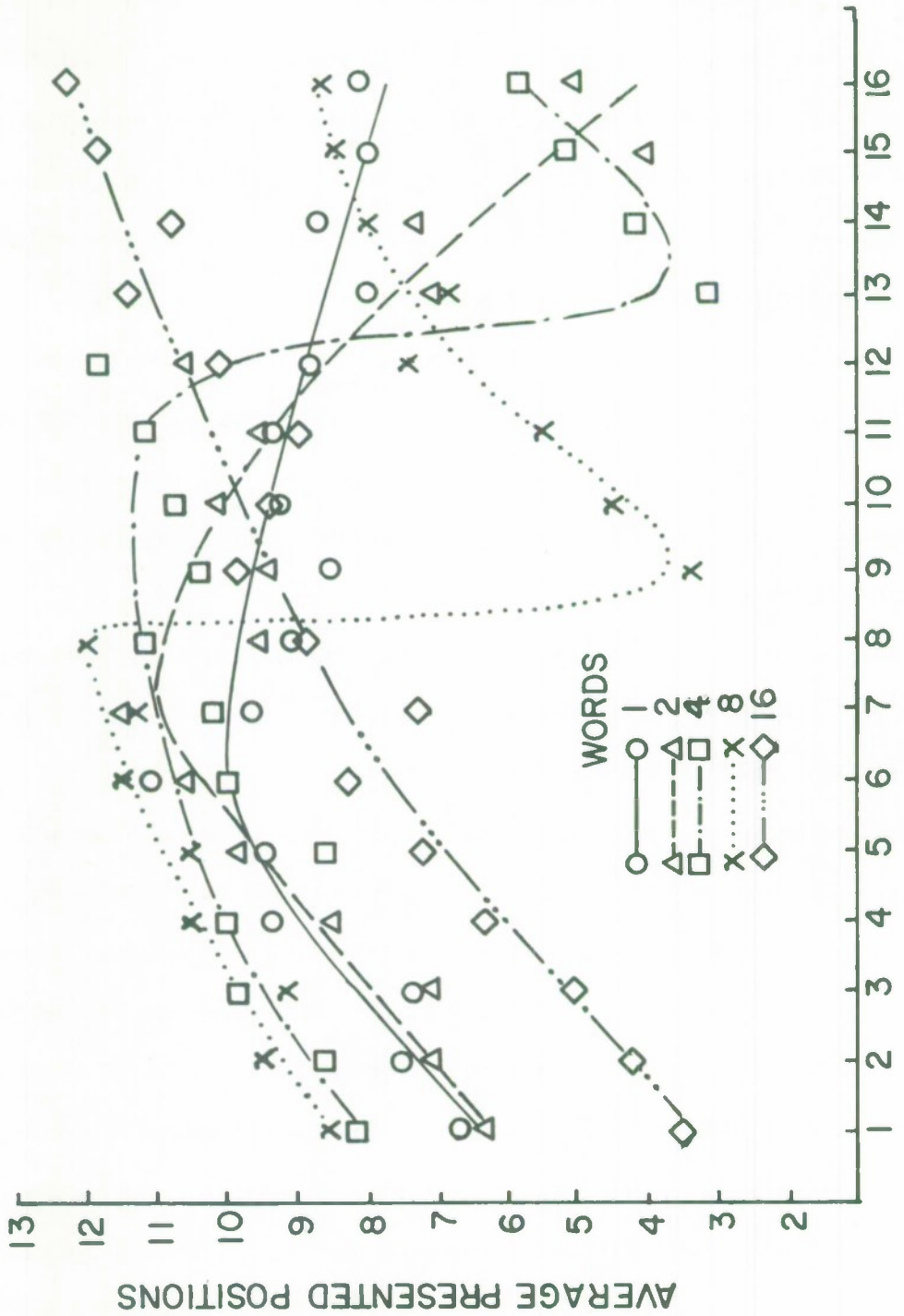

Figure 2. The average positional order of the responses as a function of the serial position of the word in the presented series.

in the order of presentation within a cluster. Only partial support is evidenced for the notion that the last cluster would be emitted first and the earlier clusters emitted nearer the end of the series on the criterion trial. The data for the 8 word series are most compatible with the prediction. Figure 2 indicates that, indeed, for that condition the later words were emitted first and typically in the cluster order. For the 2 and 4 word conditions it appears that Ss on the average start near the middle of the series, but in the order of the cluster, work toward the end, and give the first cluster last. It was expected that there would be a tendency to respond somewhat in presentation order for the 16 word series, but the extreme regularity of the response order was greater than anticipated.

As was pointed out there are no significant differences between groups in trials to criterion. Criterion is met in virtually the same number of trials for the 2 and 4 word conditions. It was expected that criterion would be met in fewer trials with the 4 word cluster since it was believed that more simultaneous associations would be developed. Since 4 words proved to be well within the memory span it was expected that there would, in fact, be fewer chunks to learn, chunks which always could be learned after but one presentation. What apparently happens is that, indeed, more simultaneous associations are made with the 4 word condition. However, since 4 words are shown simultaneously, relatively strong associations form between non-adjacent words within the cluster in addition to adjacent words. In other words, the number of simultaneous

associative units learned to a word in a group is greater than that for the 2 word condition. The additional associations, therefore, possibly might build up excessive amounts of interference within a cluster since 4 words are within the memory span, and hence, somewhat reduce the apparent enhancement of the learning process at this level.

Summary

Four questions were investigated in this study. (1) Is the learning rate enhanced if disconnected words are presented visually in clusters, e.g., pairs of quadruples, rather than individually and successively? (2) If changes do occur, and in a lawful fashion, can such differences be accounted for adequately in terms of the development of differential interitem association strengths as a function of such stimulus arrangement? (3) What differences, if any, become evident in free-recall serial position curves by such organization? (4) How is the order of responding affected by clustering?

It was found that clustering will enhance learning rate, but that the limits are extremely restricted. Furthermore, it was revealed that such stimulus arrangements do affect the build-up of differential interitem association strengths, but this again is within the limits alluded to above. Apparently, differential associative strengths developed by clustering markedly affect the shapes of the serial position curves for the different groups. Further, clustering affects the strategy an individual adopts in responding. Such became evident in the typically different orders of responding for the various conditions.

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